針對馬達控制和數位電源應用的STM32微控制器系列
STM32 for Digital Power and Motor Control Application

Anicet GIAIMO

技術行銷經理
意法半導體

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STM32 for Digital Power
and Motor Control Application

- Introduction to Digital Power
  - Application and benefit
  - MCU requirement for Digital Power Control
  - STM32 key ingredient for digital power
- STM32 for Digital Power Application
  - STM32F334 Digital Power Product Line
  - STM32 Digital Power Ecosystem
    - Hardware and Firmware
    - 500W DSMPS, 2kW DSMPS
    - Documentation

Introduction to Digital Power

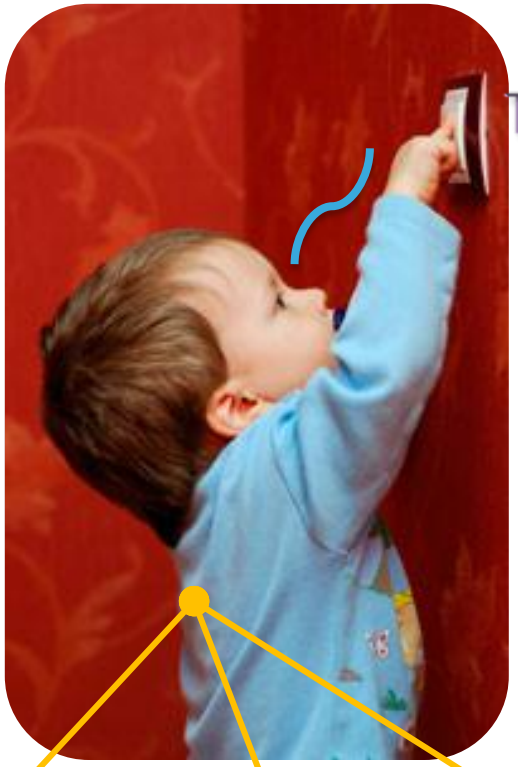
What is Digital Power Control?

PROCESSING

ACTUATION

SENSING

COMMUNICATION



Cortex-M

TIMER PWM

ADC

UART/I2C/SPI
…

SMART

ENERGY SAVING

HIGH INTEGRATION

Introduction to Digital Power

Power Conversion Applications

Lighting

Adapters

Wireless charger

Servers

Digital Power Control Achieved by STM32 broad Portfolio

Welding

Telecom power

Industrial

UPS and
PV inverters

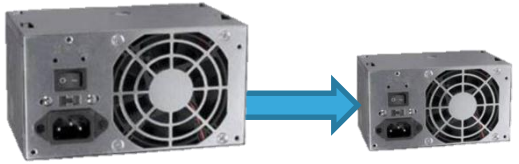
Introduction to Digital Power

- Benefit of digital control for power conversion
  - Energy saving
    - Increase the power efficiency
  - High Integration
    - Increase the power density
  - Smarter design
    - Control adaptability
    - Make your design more flexible
  - Less components
    - Simplify your design
    - Reduce your BOM cost
    - Increase the value of your product

Efficiency

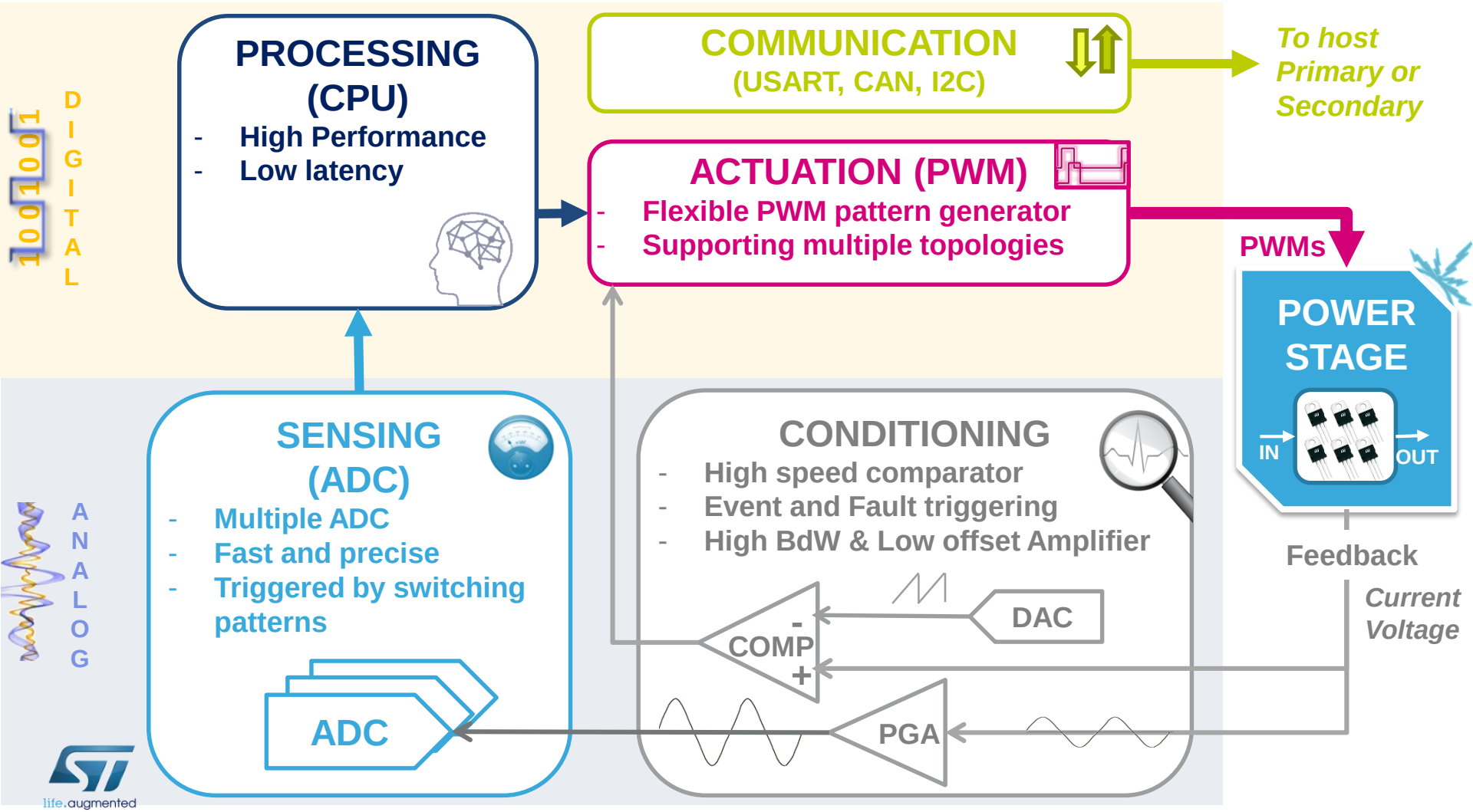
Energy saving

Power density



STM32 & Digital Power

MCU requirements for Power Control



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STM32 & Digital Power

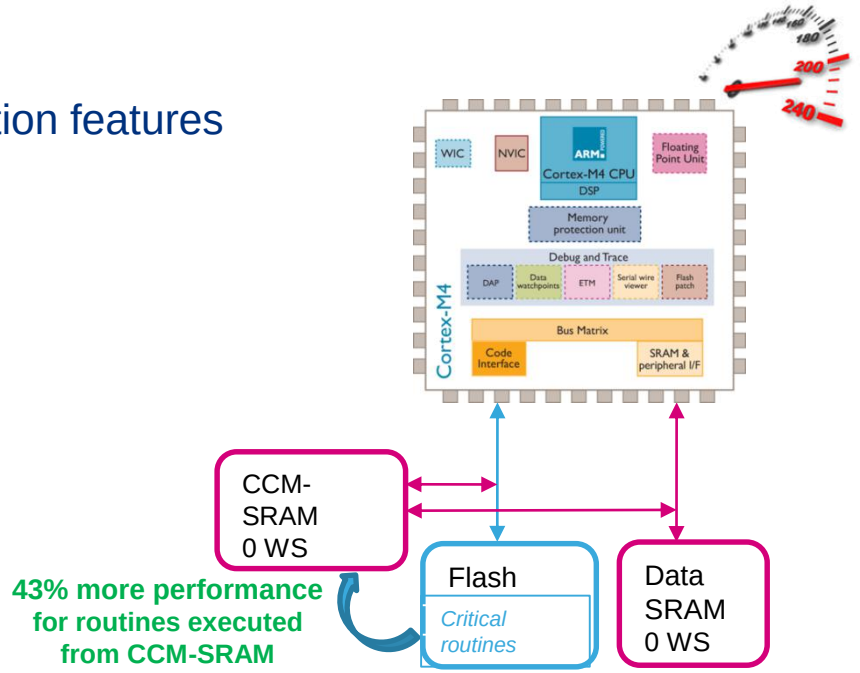
PROCESSING

STM32 key ingredients for power control

- Select the right core within STM32 **broad pin-to-pin portfolio**

Cortex-M0/M0+	Cortex-M3	Cortex-M4	Cortex-M7
32bit performance at competitive price	Cortex-M Foundation	High performance with DSP & FPU	Very high performance

- Take advantage of STM32 unique acceleration features
  - CCM-SRAM: SRAM on instruction bus
    ➔ boosts critical routines
  - ART Accelerator
    ➔ cache memory
  - DSP & FPU



STM32 & Digital Power

STM32 key ingredients for power control

DIGITAL

1 0 0 1 0 0 1

COMMUNICATION
CAN
Fast USART
I2C **PMBus ready**

ACTUATION (PWM)
Advanced Motor Control Timer
144Mhz (6.9ns)
High Resolution timer (217ps)

PROCESSING

Cortex
Intelligent Processors by ARM

DSP FPU

SENSING
12bit ADC SAR 5MSPS
16bit ADC Sigma Delta

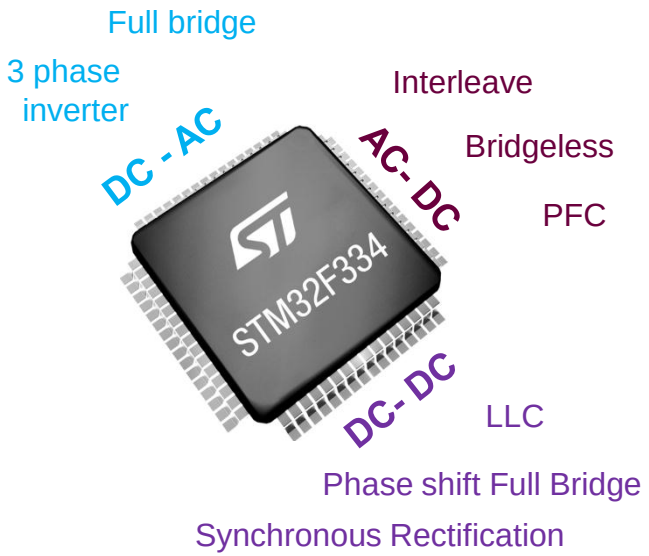
CONDITIONING
Embedded Comparator
& Op-Amp

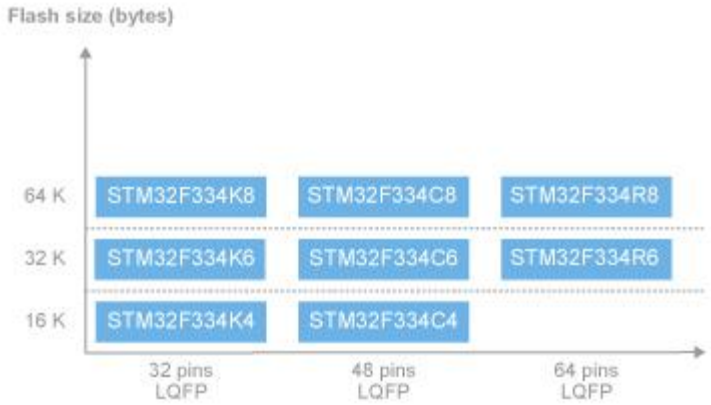
ANALOG

STM32F334
Digital Power Product Line

- STM32 Digital Power Product Line: STM32F334
  - **Supporting complex topologies**
    - Multi-phase, interleaved
    - Control up to 10 power switches
  - **High-resolution timers**
    - Improve control precision
    - Increase efficiency and power density
  - **New PWM features**
    - Burst Mode Hardware controller
    - Push Pull Hardware controller
    - Banking/windowing
  - **Lower reaction time**
    - Ultra fast comparator with direct path to PWM outputs
    - Protection and cycle by cycle Event Control

In Production





STM32F334
Digital Power Product Line

- STM32 Digital Power Product Line: **STM32F334**

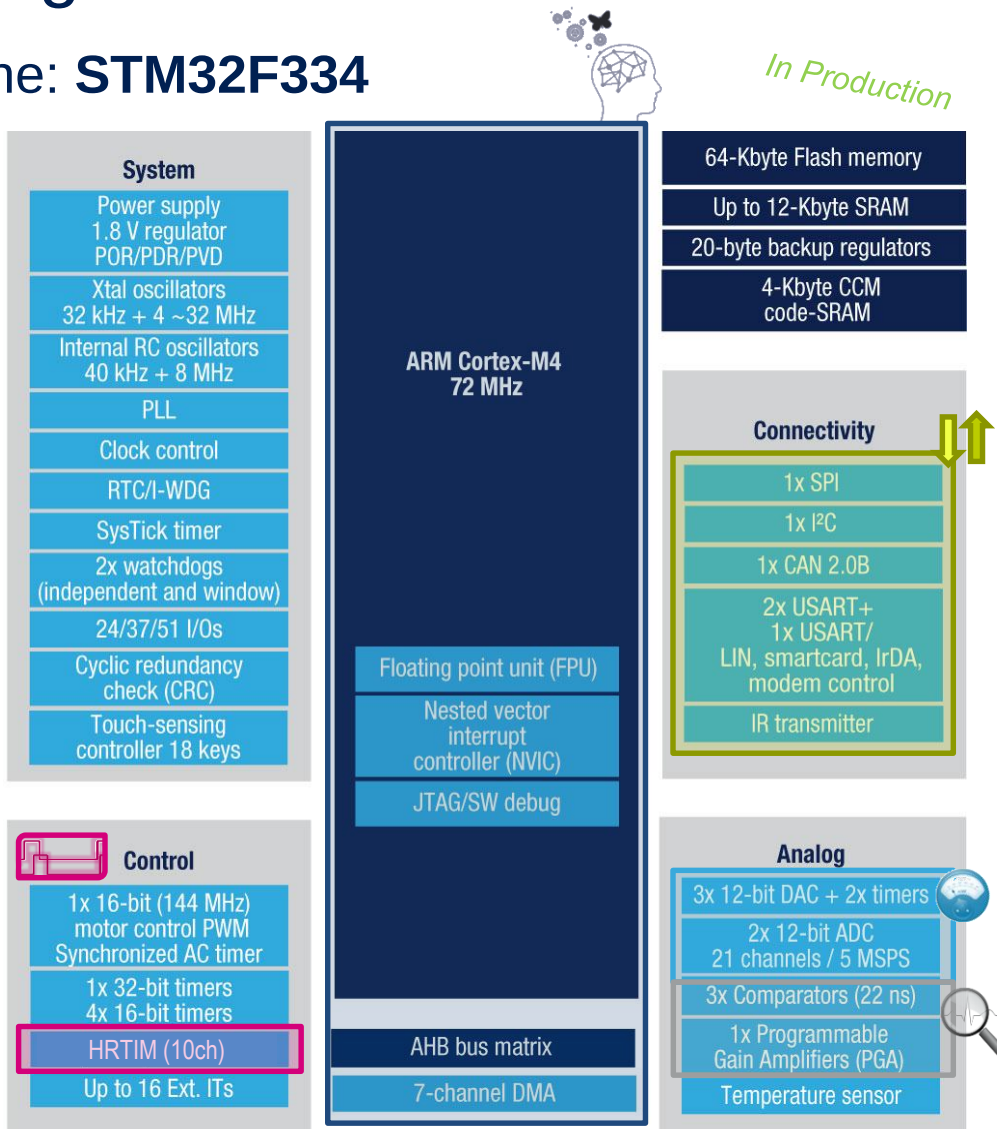
In Production

DIGITAL

- **PROCESSING: ARM Cortex-M4**
  - With **DSP** instruction and **FPU**
  - **Up to 90DMIPS***
- **ACTUATION: High Resolution TIMER**
  - **217ps High resolution**, self compensated
  - **Drift free** vs voltage, temp or manufacturing
  - Advanced **PWM waveform generator**
  - Complex event management

ANALOG

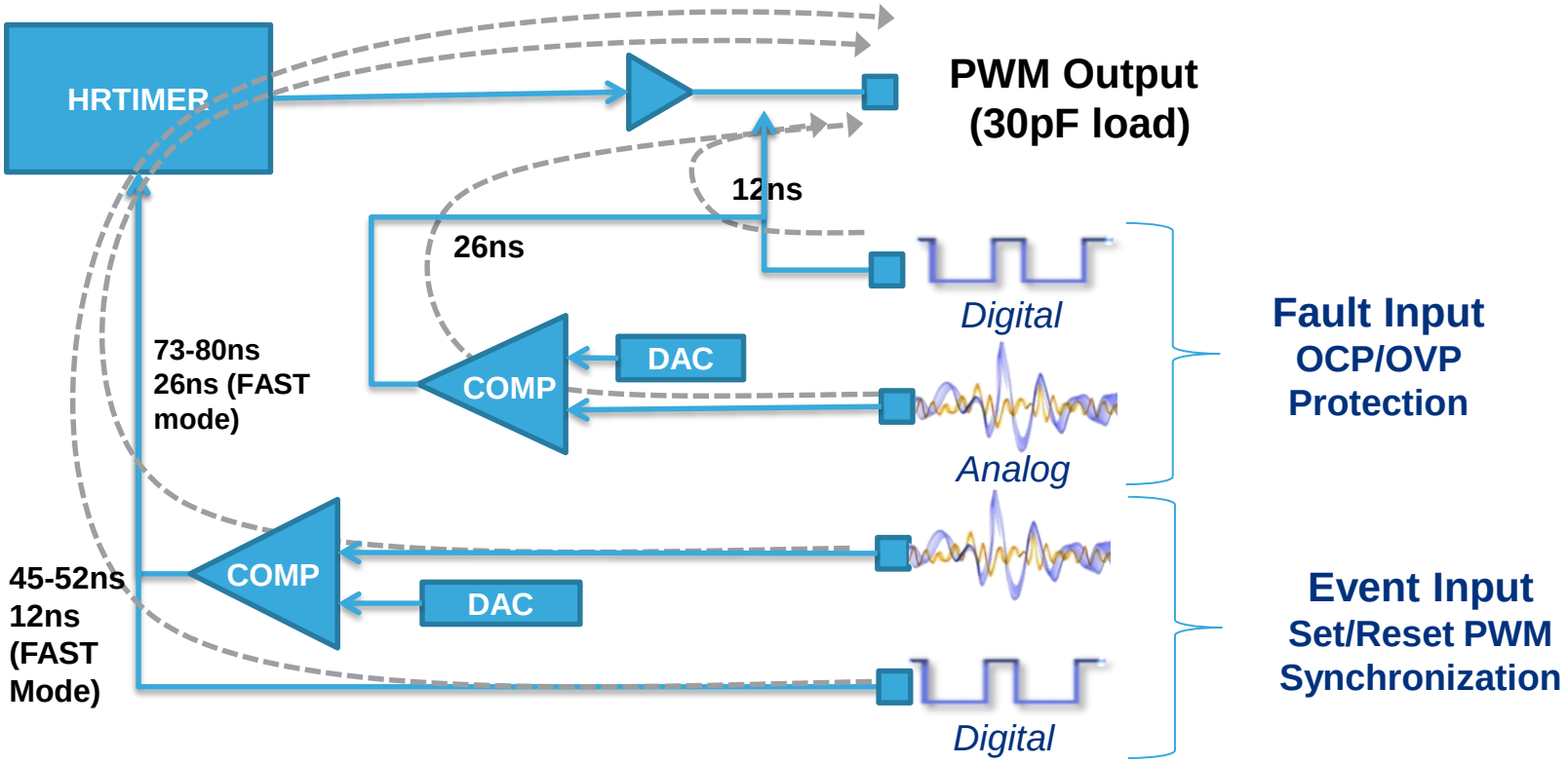
- **SENSING: Precise/Hi-Speed ADC**
  - **12bit SAR 5MSPS** single end and diff. inputs
  - Down to 21ns Sampling time
  - Multiple trigger for PWM
- **CONDITIONNING: COMP & PGA**
  - **Ultra Fast Comparator** (26ns)
  - **Op-Amp** with built-in Gain (PGA)



* *From CCM-RAM*

STM32F334
Digital Power Product Line

- STM32F334: High Resolution Timer response time

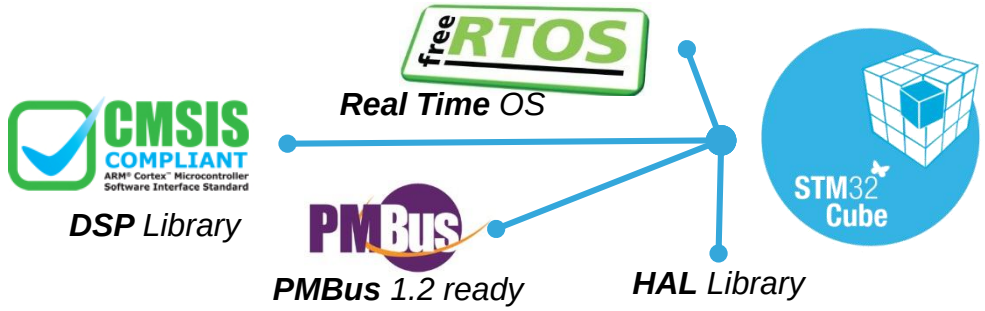


STM32 Digital Power
Ecosystem Overview

- STM32F334 Dedicated Eco-system
  - Set of evaluation boards:

NUCLEO	DISCOVERY	500W DSMPS eval	2KW DSMPS eval
Prototyping	Lighting Demo Buck-Boost Demo	Semi-bridgeless PFC LLC + SR	Interleave PFC Phase Shift Full Bridge + SR
NUCLEO-F334R8	32F3348DISCOVERY	STEVAL-ISA147V2	*Available Q4 2015*

  - Software (including library, middleware and examples)
    - HAL library
    - RTOS
    - DSP library and PMBus ready
    - Full set of examples
  - PC tools:
    - CubeMx: Configuration tool
    - STMStudio: On-the-fly variable monitoring (validation and debug)



STM32 Digital Power Ecosystem

500W DSMPS

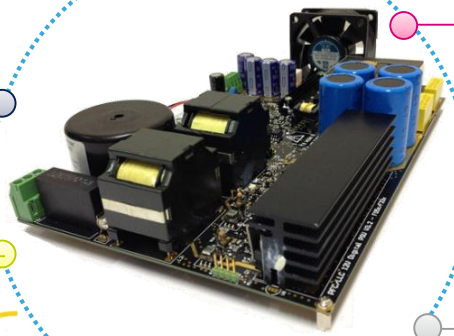
- STEVAL-ISA147V2: Key messages

Main features

Full Range AC Input
PFC output voltage: 430V DC
PFC switching frequency: 60 kHz
DC/DC switching frequency:76kHz/130kHz
Output voltage: 12V DC
Peak efficiency : 93.5%

Full digital control

STM32F051 for PFC
STM32F334 for LLC & SR



STEVAL-ISA147V2

All essential protection features

Higher reliability, thanks to fast protections

Short Circuit protection
Over current/voltage Protection

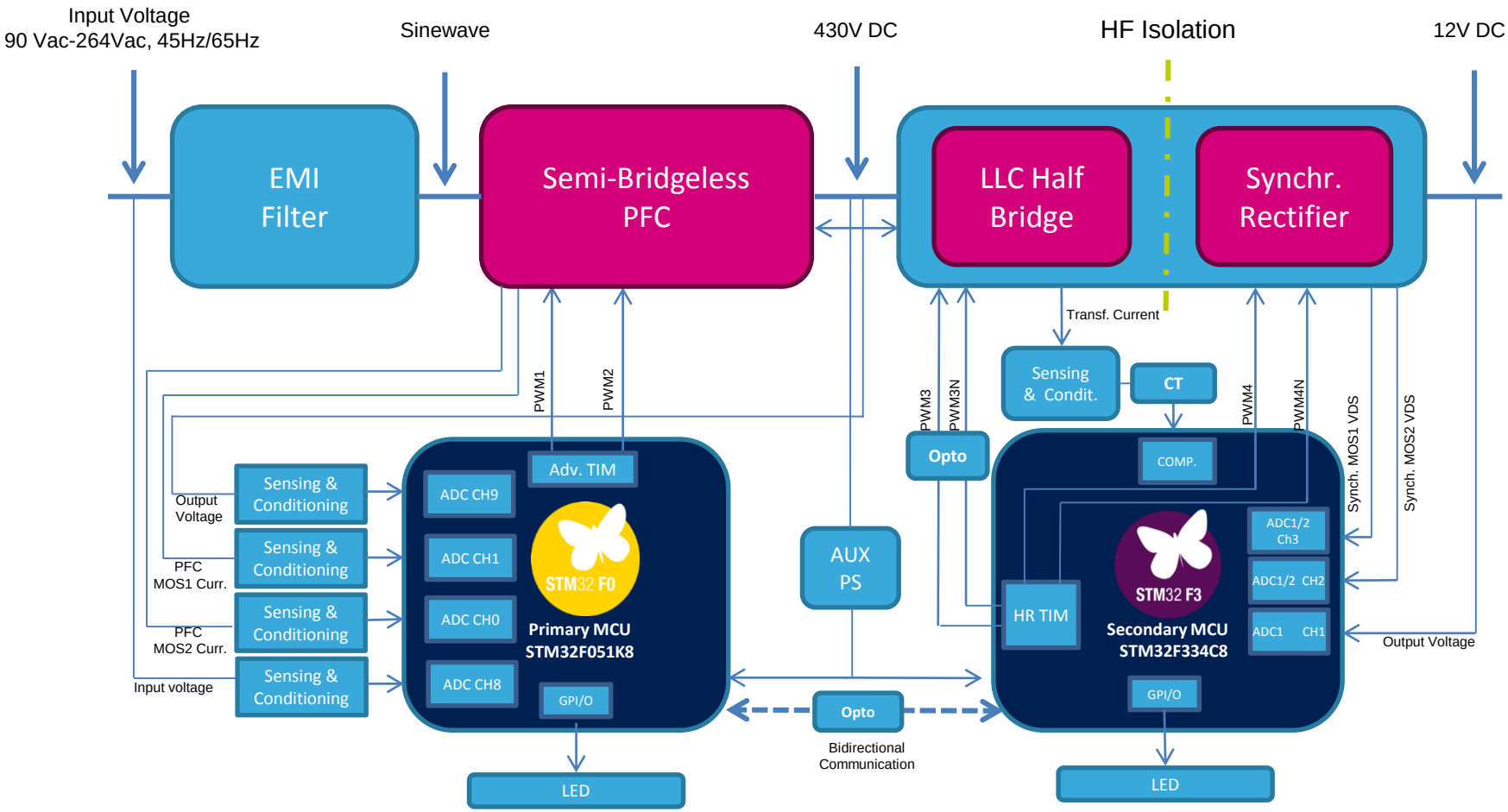
Boosted peak and light load efficiency

In line with the stringent requirements of the power supply industry. 80+ Platinum compliant at 115 Vac

STM32 Digital Power Ecosystem

500W DSMPS

- STEVAL-ISA147V2: Block Diagram



STM32 Digital Power Ecosystem

2kW DSMPS

- 2KW DSMPS EVAL: Key messages

Main features

Full Range AC Input
PFC output voltage: 400V DC
PFC switching frequency: 60 kHz
DC/DC switching frequency:100kHz
Output voltage: 48V DC
HF transformer isolation:4 kV

Full digital control

STM32F334 for PFC
STM32F334 for DC/DC & SR

All essential protection features

Higher reliability, thanks to fast protections

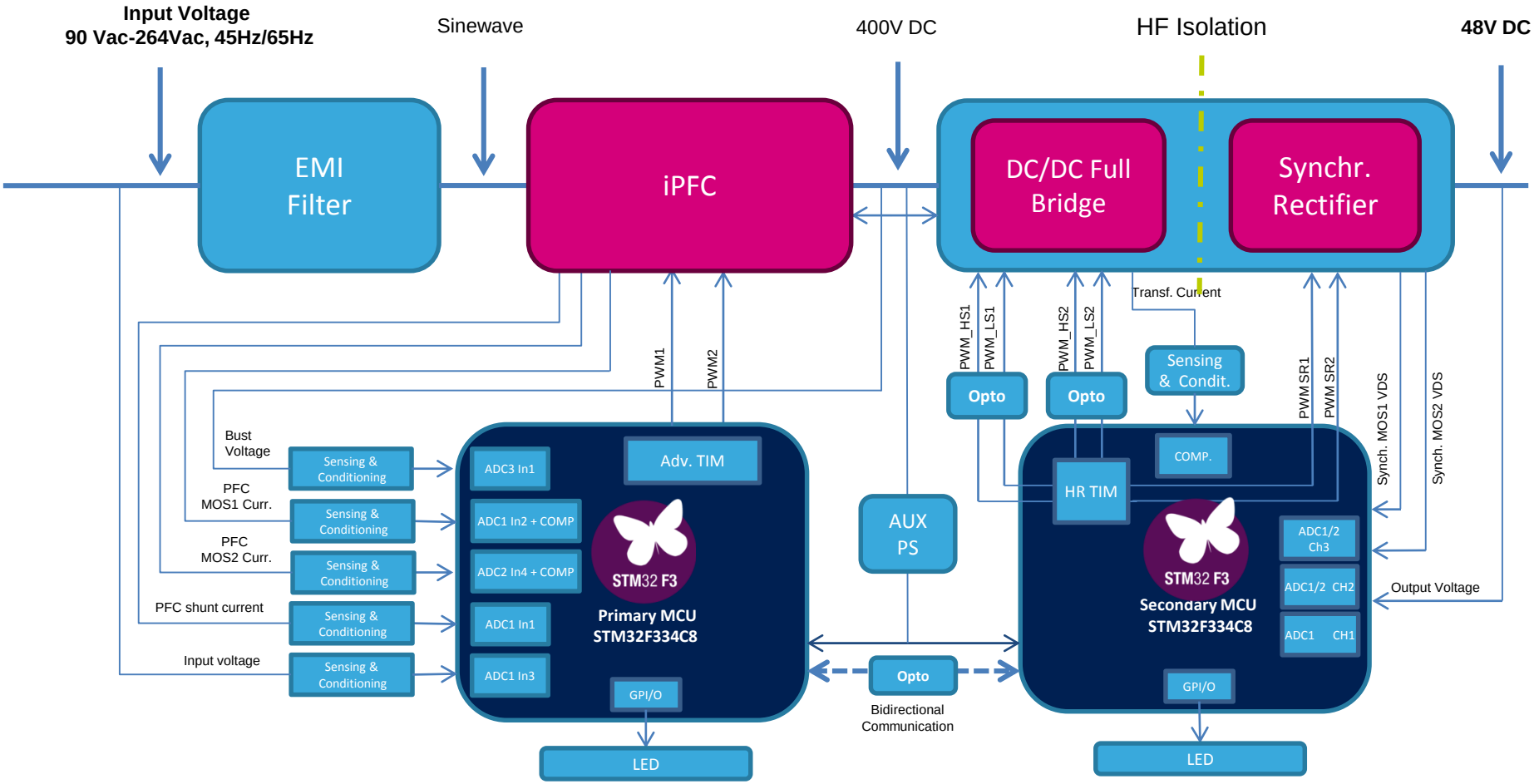
Short Circuit protection
Over current/voltage Protection
Over temperature Protection

Boosted peak and light load efficiency

STM32 Digital Power Ecosystem

2kW DSMPS

- 2KW DSMPS EVAL: Block Diagram



STM32 Digital Power Ecosystem
Documentation

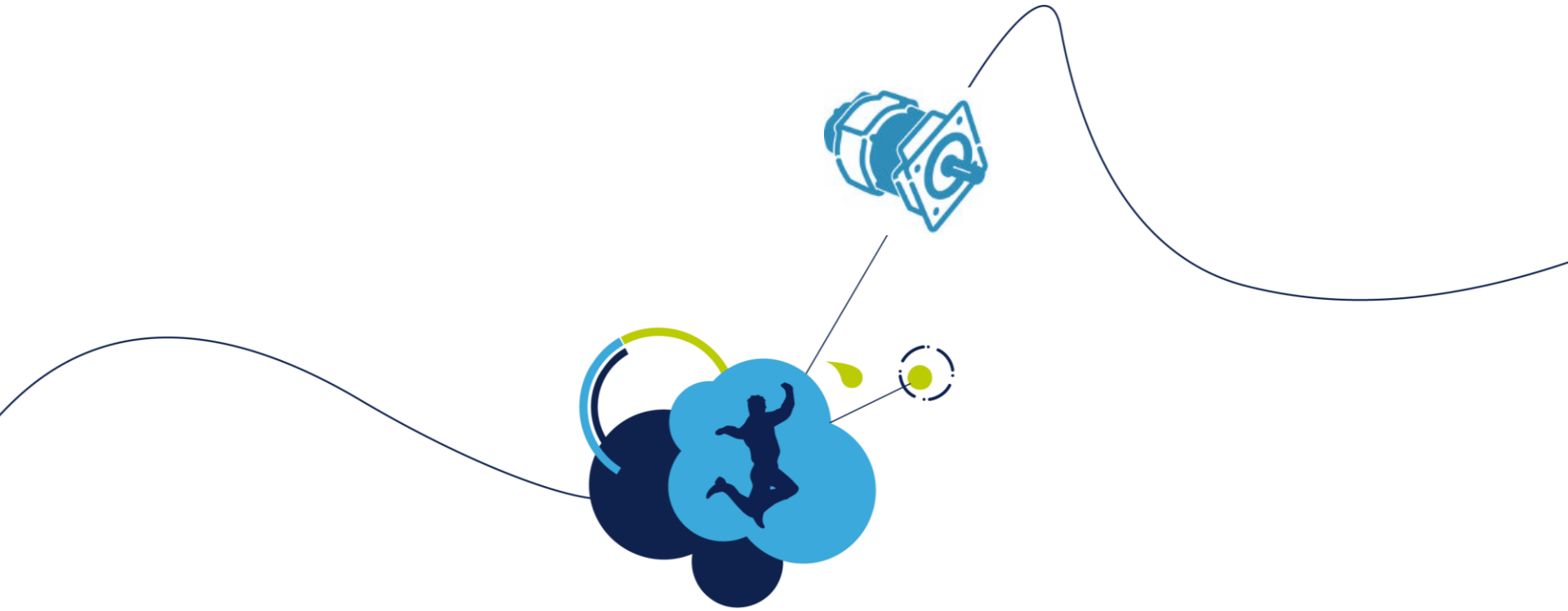
- Digital Power documentation
  - Complete HW/FW application notes
    - **HRTIMER cookbook**
      How to operate HR timer in different topologies
      Including firmware examples
    - **Buck-Boost converter with F334 discovery kit**
      Including Hardware and Firmware description
    - **High Resolution LED dimming with F334 discovery kit**
      Including Hardware and Firmware description
    - **500W DSMPS (ISA147V2)**
      Including Hardware and Firmware description
  - And also user manuals and getting started manuals
    - UM1733: Getting started with F334 discovery
    - UM1736: Getting started with F334 software
    - UM1735: Discovery kit user manual
    - UM1746: 500W DSMPS user manual

AN4539
HRTIM Cookbook

AN4449
Buck-Boost converter F334 Discovery kit

AN4539
High Resolution LED Dimming F334

AN4468
500W fully digital F334 AC-DC PSU



STM32 and Motor Control Application

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STM32 for Digital Power
and Motor Control Application

- Introduction to motor control
  - Application
  - STM32 & Motor control
  - Motor classification

- STM32 Motor Control ecosystem
  - FOC PMSM Firmware library
  - ST Motor control workbench
  - Hardware solutions

Introduction
to Motor Control Application

Motion Control

Efficient motor control solutions

Motor Control

- **Industrial Drives** — Robotics, HVAC, pumps, CNC.
- **Home appliances** — White Goods, Refrigerators, Room air conditioning
- **Motor Control** — Fitness, Healthcare, Pedelec and more

A complete offer of ST devices

(IPMs) SLLIMM™

- Diodes
- Power transistors
- Gate Drivers

- Control unit
- AC switches
- Sensors
- Motor driver ICs
- Power Management

Motor Control libraries

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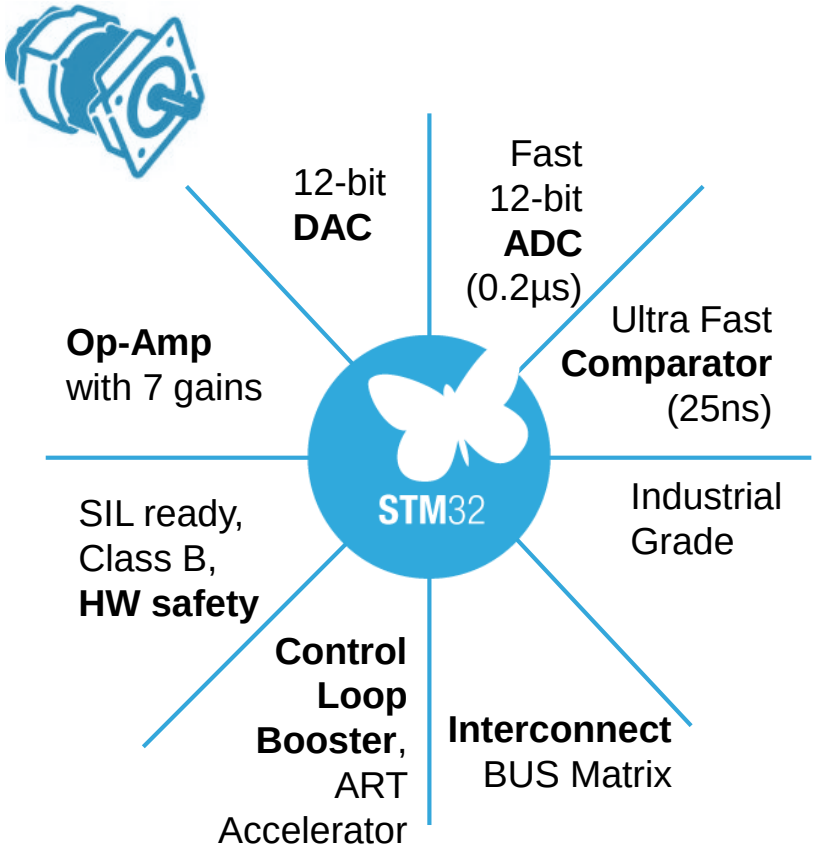
Introduction to Motor Control

STM32 Shaped for Motor Control

STM32: THE Cortex-M based MCU family shaped for Motor Control



From entry level (F0 series) to very-high performance (F7 series)

All STM32F devices equipped with advanced Motor Control timer(s)

Rich and advanced analog integration especially in STM32 F3 series sized for control loop

From 16 KBytes up to 2 MBytes in various packages

Introduction to Motor Control

STM32 Shaped for Motor Control

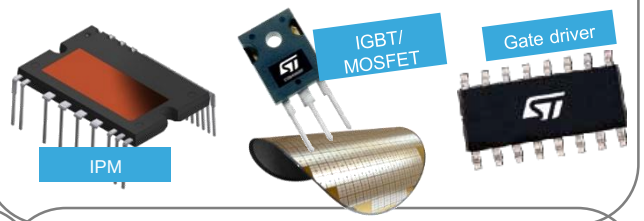
Ready to use ST Solution for Motor Control

MCUs for Motor Control (8-32 bit)

STM32 | STM32 F3 | STM32 F0 | STM32 F1 | STM32 F4

MC FW Library

Inverters IPM / discretes



ST MC Workbench

PC SW GUI
Full customization and real time communication

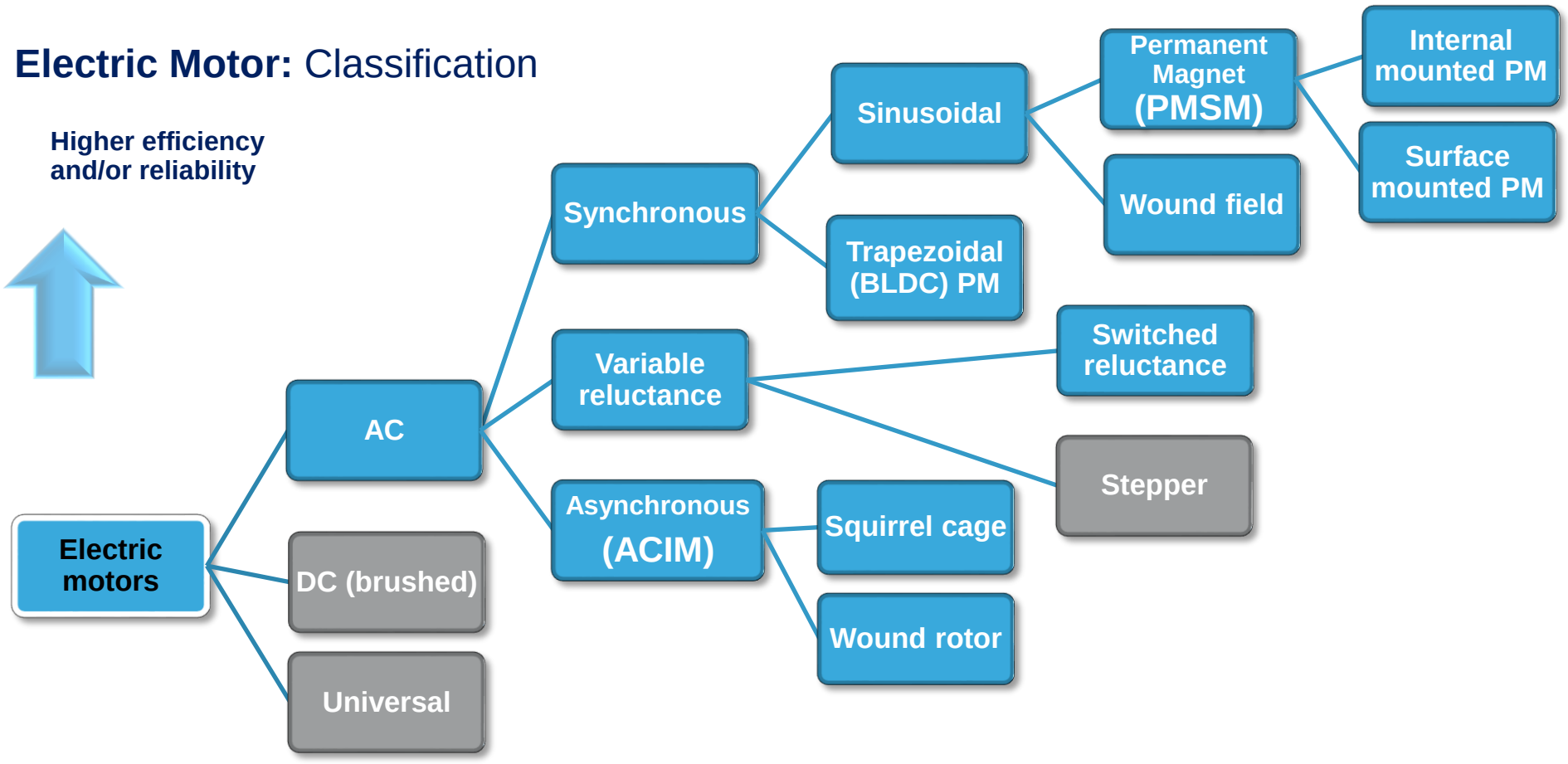
Broad range of algorithms for specific applications (FOC – 6step)

HW & SW tools

Technical Support (WW level)

Introduction to Motor Control

Electric Motor: Classification



- **PMSM:** 3-phase permanent magnet synchronous motor
- **ACIM:** 3-phase induction motor

Limited computation needs
Driving method well-known, mastered by customer
Light ecosystem
Basic ADC/PWM requirement

Computation intensive
Complex driving, requires specific knowledge and/or support
Complete ecosystem necessary
Requires 3-phase timer + sync'd ADC

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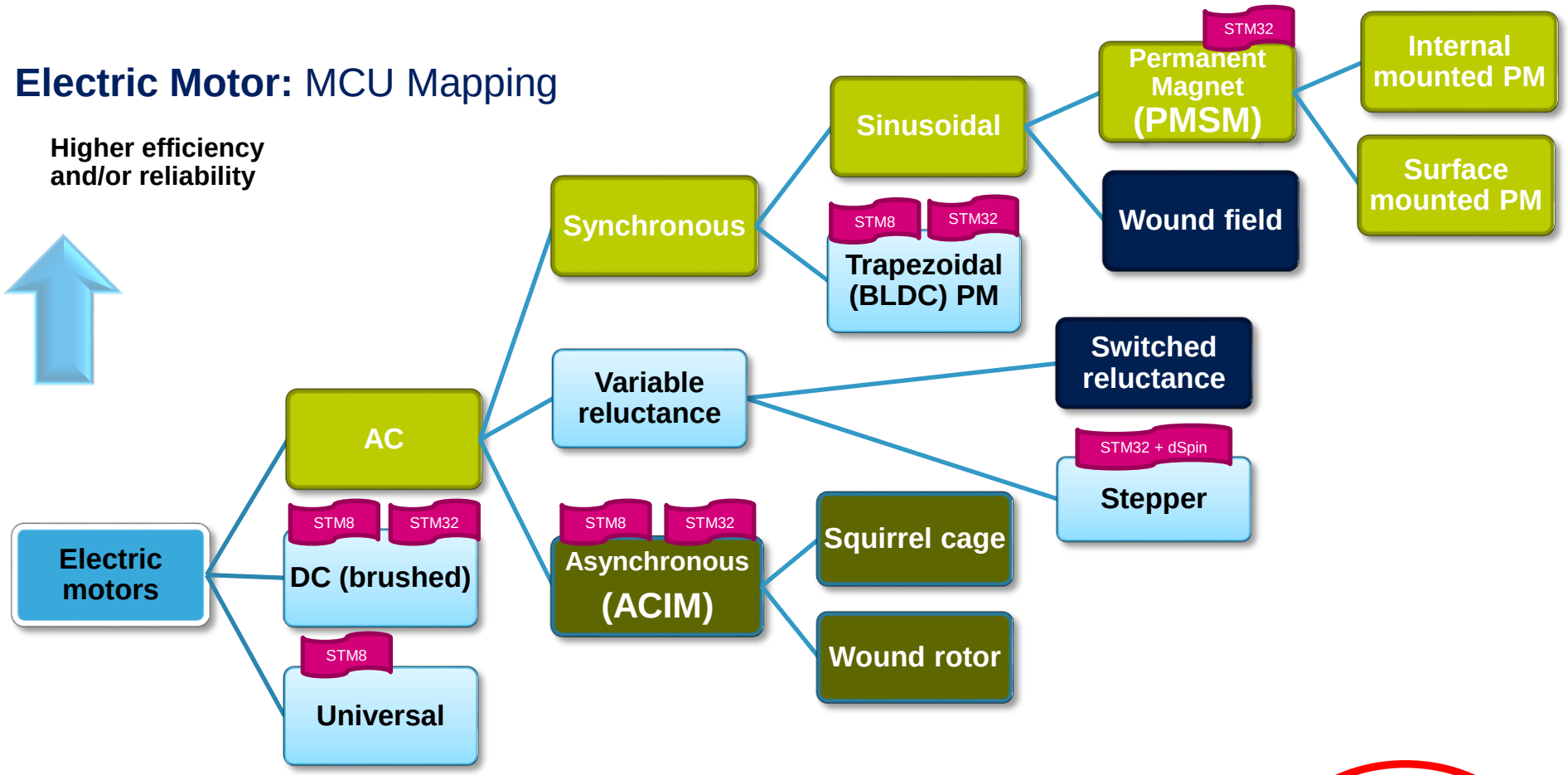
Introduction to Motor Control

Electric Motor: MCU Mapping



- **PMSM:** 3-phase permanent magnet synchronous motor
- **ACIM:** here 3-phase induction motor

Solution available today

Supported with ST products but no ecosystem

Solution available (HW & SW)

Complete Motor Control ecosystem (FW Library **V4.x**)

Complete Motor Control ecosystem (FW library **V2.x**)

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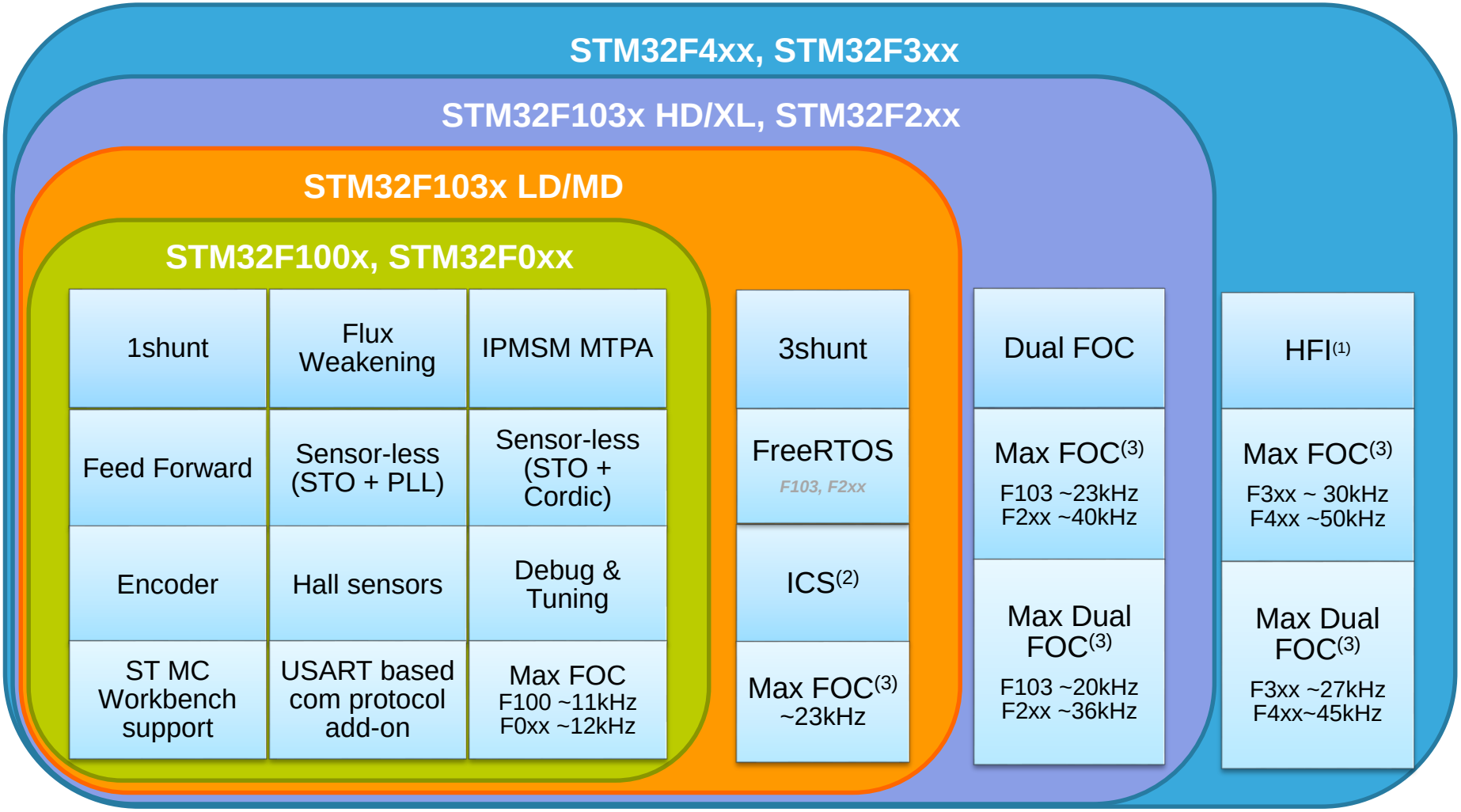
STM32 FOC PMSM FW lib

Motor Control Firmware Features



(1) High Frequency Injection

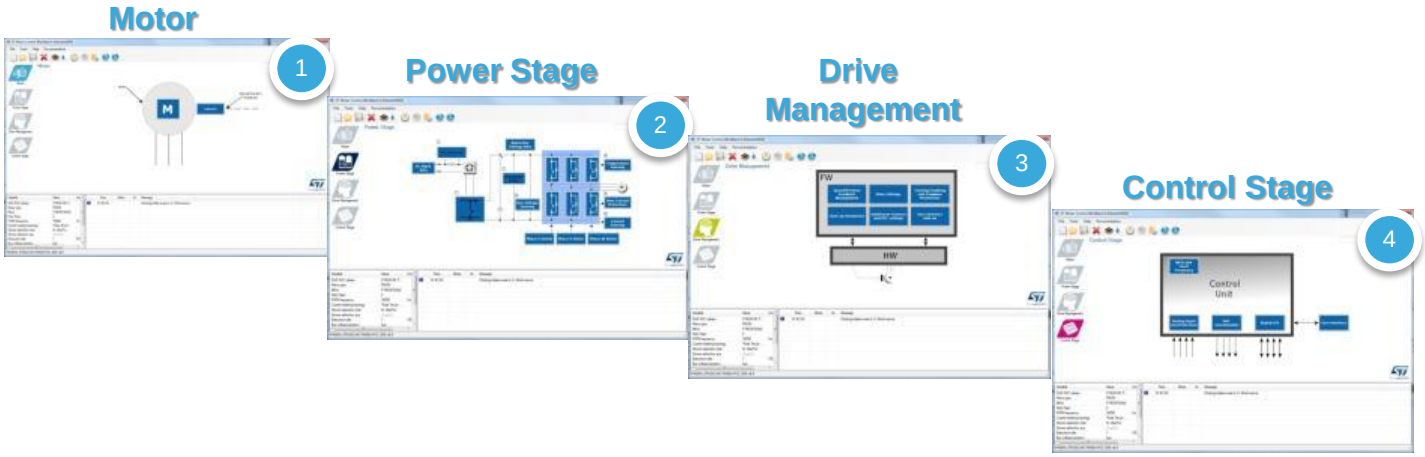
(2) F1, F2, F4

(3) Max FOC estimated in sensorless mode

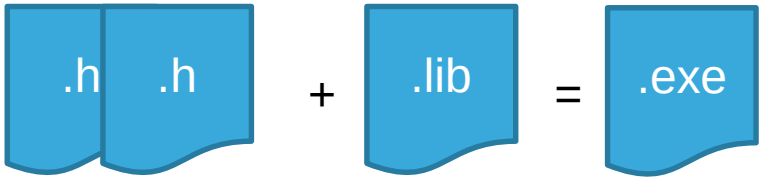
STM32 FOC PMSM FW lib

ST MC Workbench

PC GUI to setup MC environment + configure the MC FW lib



Configure the MC FW lib parameters in 4 steps



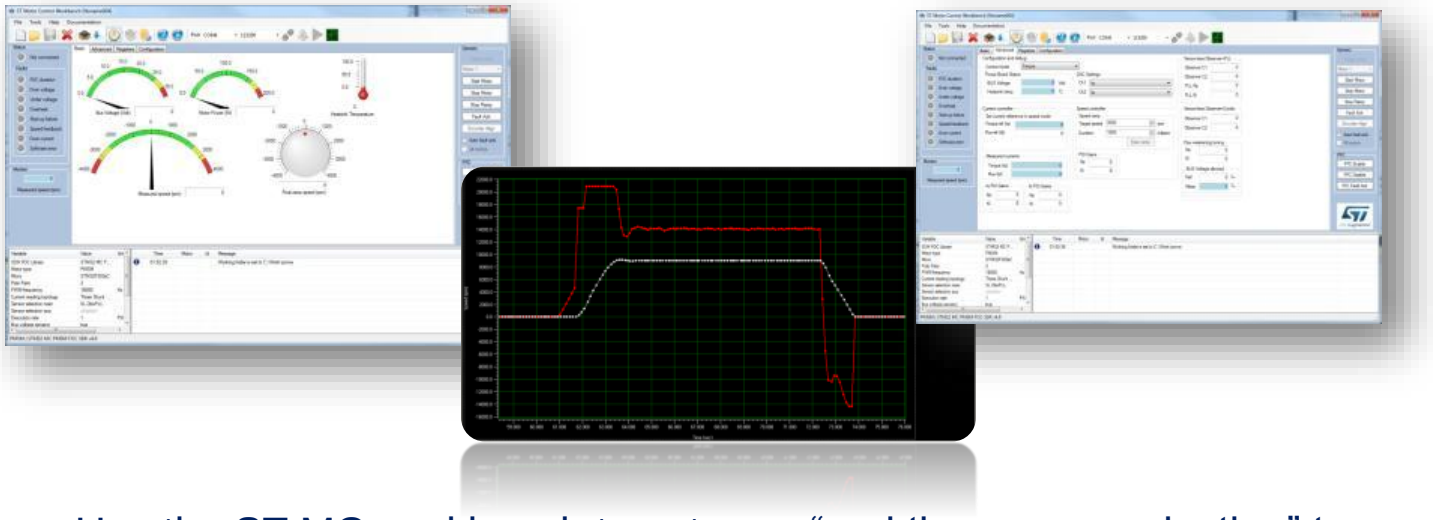
Generate source code project and compile

RUN the motor

STM32 FOC PMSM FW lib

ST MC Workbench

Real time tuning

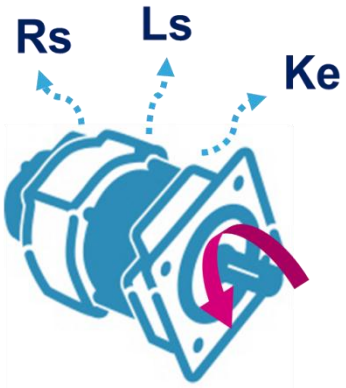


- Use the ST MC workbench to set-up a “real time communication” to send start/stop commands or to set a speed ramp.
- Debug or fine tuning motor control variables (like speed PI parameters) can be assessed using the advanced tab.
- Plot significant motor control variables (virtual oscilloscope) like target or measured motor speed.

STM32 FOC PMSM FW lib

Motor Profiler + One Touch Tuning

Plug and Spin your Motor in less than 1 minute !



- Automatic detection of key parameters
- Zero equipment required
- Spin motor within < 1min.

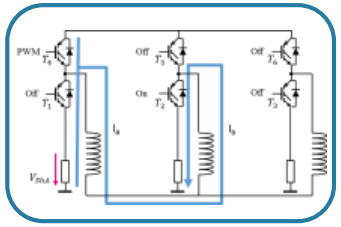
- Single parameter to tune the speed controller
- Wide speed range
- Adapting to various load/inertia

STM32 FOC PMSM FW lib

Motor Profiler + One Touch Tuning

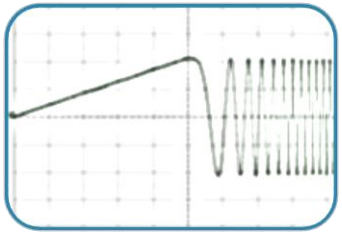
Plug and Spin your Motor in less than 1 minute !

Motor stopped
- Rs measurement
- Ls measurement
- Current regulators set-up



10 sec

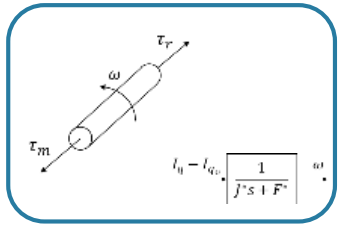
Open loop
- Ke measurement
- Sensorless state observer set-up
- Switch over



5 sec

1 minute !

Closed loop
- Friction coefficient measurement
- Moment of inertia measurement
- Speed regulator set-up



45 sec

STM32 FOC PMSM FW lib

Motor Startup “on-the-fly”

- Ready for Fan and Air-Con
- This Motor Startup “on-the-fly” algorithm provides smooth sensorless FOC drive insertion in applications where the rotor is already rotating. A typical application is an outdoor fan (Air Con, Smoke extractor and more).
- Related benefits:
  - Reliable starts up.
  - Reducing noise and mechanical vibration/noise
  - Efficient drive

Hardware Ecosystem

System Approach

Flexible MC Platform

Control stages

Power stages

Complete MC drives

STM32 Nucleo + X-NUCLEO

MC KIT

MC Software Development Kit (SDK)
(FW library, GUI, collateral materials)

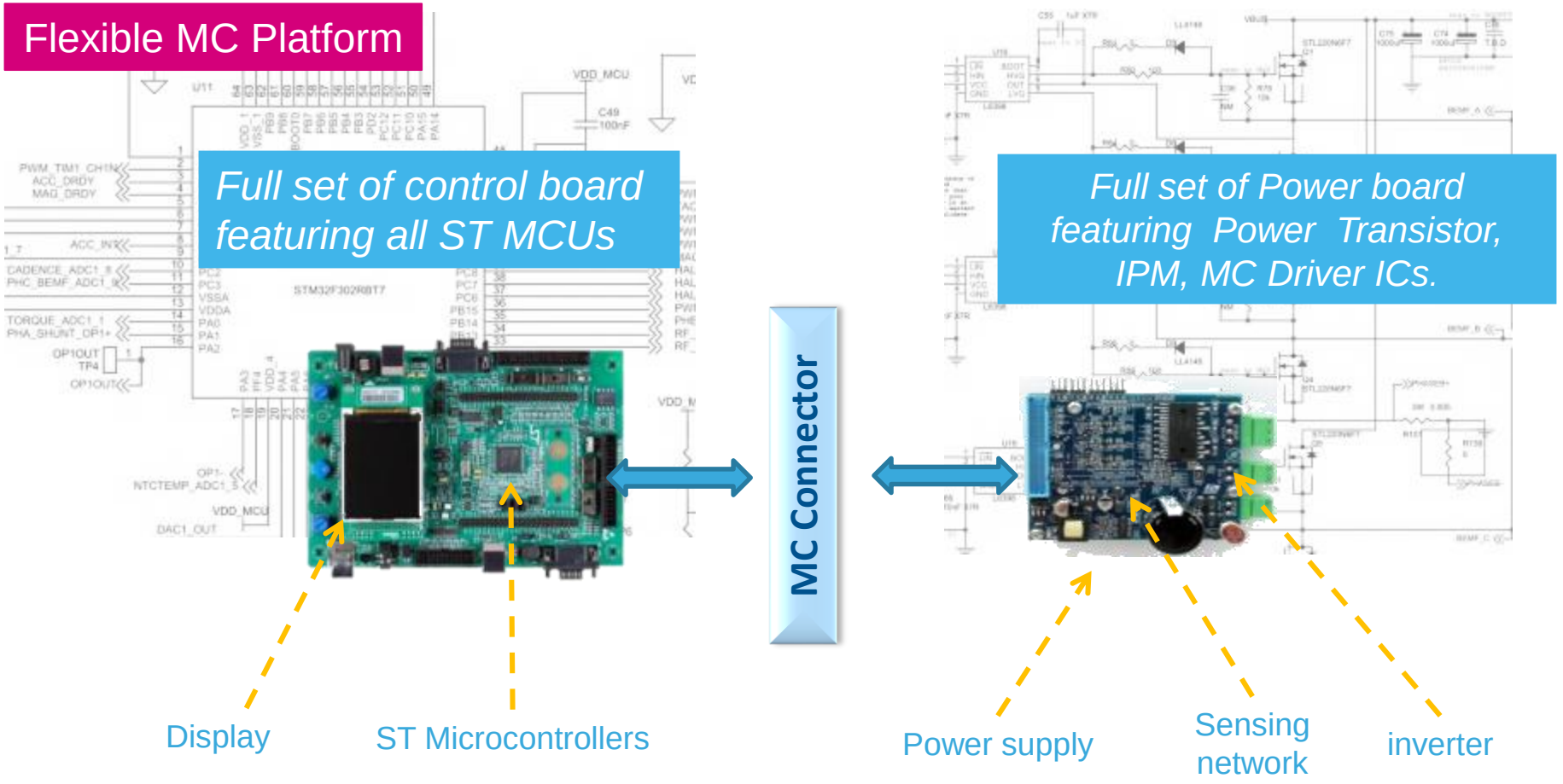
Hardware Ecosystem

Building Your Evaluation Kit

Flexible MC Platform

Full set of control board featuring all ST MCUs

Full set of Power board featuring Power Transistor, IPM, MC Driver ICs.



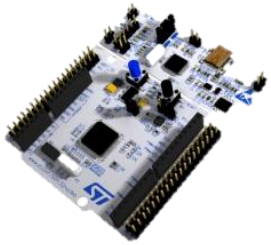
Hardware Ecosystem

New Motor Control Nucleo Pack

Low Voltage MC kit for PMSM/BLDC motor

Available e/o Q4-2015

NUCLEO-F302



X-NUCLEO-IHM07M1*

All in one blister

LV BLDC Motor

- Fast & safe prototyping
- Affordable for everyone

Main features

- 3-Phase motor control application (up to 50V,1.4 A)
- 6 Step modulation - FOC FW library compatible with STM32Cube MX
- Vector drive control – ST PMSM FOC SDK (STSW-STM32100)

Expansion Nucleo Board with STSPIN L6230 (up to 50V,1.4 A)

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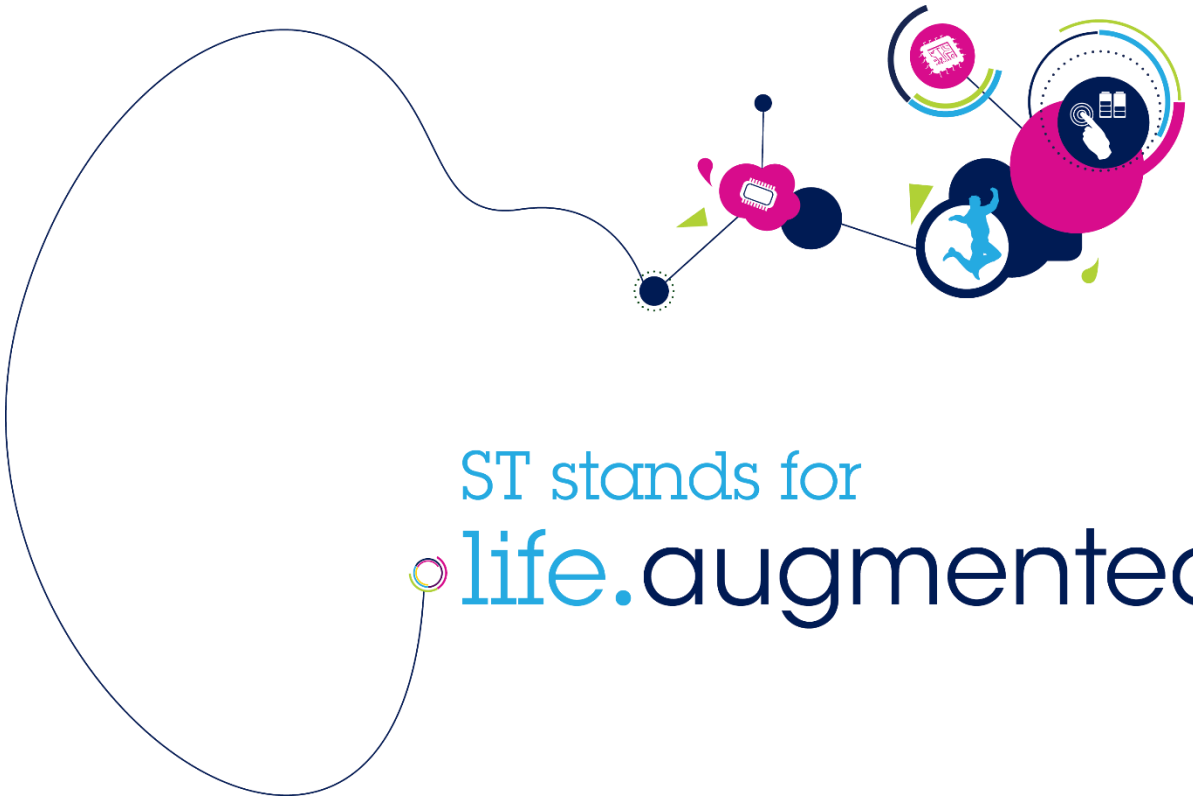
Thank You



ST stands for

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